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Kim et al.

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(54) **AIR CONDITIONER AND CONTROL METHOD THEREOF**

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(51) **Int. Cl.**

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F25B 30/02	(2006.01)
F25B 45/00	(2006.01)
F25B 1/10	(2006.01)
F25B 13/00	(2006.01)

(52) **U.S. Cl.**

CPC . ***F25B 30/02*** (2013.01); ***F25B 1/10*** (2013.01); ***F25B 13/00*** (2013.01); ***F25B 45/00*** (2013.01); *F25B 2313/02741* (2013.01); *F25B 2400/13* (2013.01); *F25B 2600/2509* (2013.01)

(58) **Field of Classification Search**

CPC . F25B 1/10; F25B 2400/13; F25B 2600/2509
See application file for complete search history.

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(57) **ABSTRACT**

Provided is an air conditioner. The air conditioner including a compressor, an outdoor heat exchanger, an indoor heat exchanger, and an expansion device includes a supercooling device for supercooling a refrigerant condensed in the outdoor heat exchanger or the indoor heat exchanger, an injection passage through which the refrigerant passing through the supercooling device is introduced into an injection inflow part of the compressor, a bypass passage extending from the injection passage to a suction part of the compressor to bypass the refrigerant, and a passage opening/closing part disposed in at least one of the injection passage and the bypass passage to selectively block a flow of the refrigerant.

10 Claims, 7 Drawing Sheets

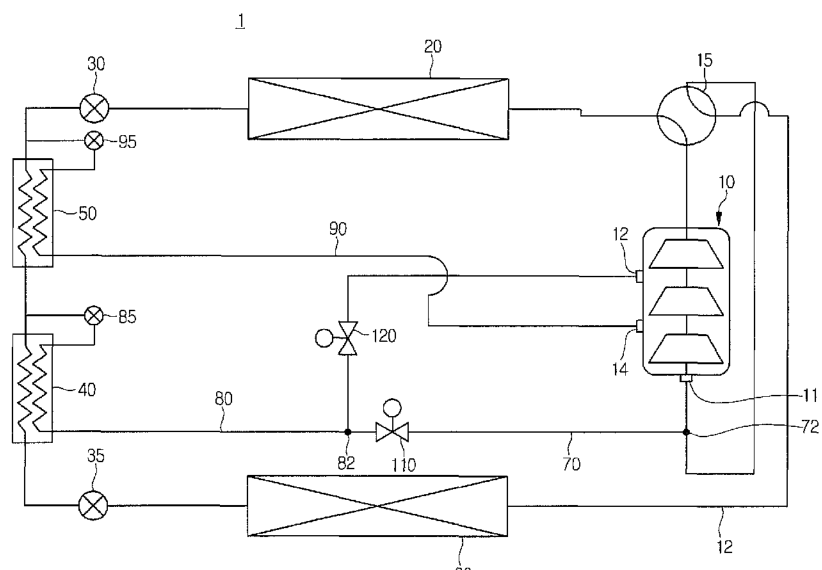


Fig. 1

1

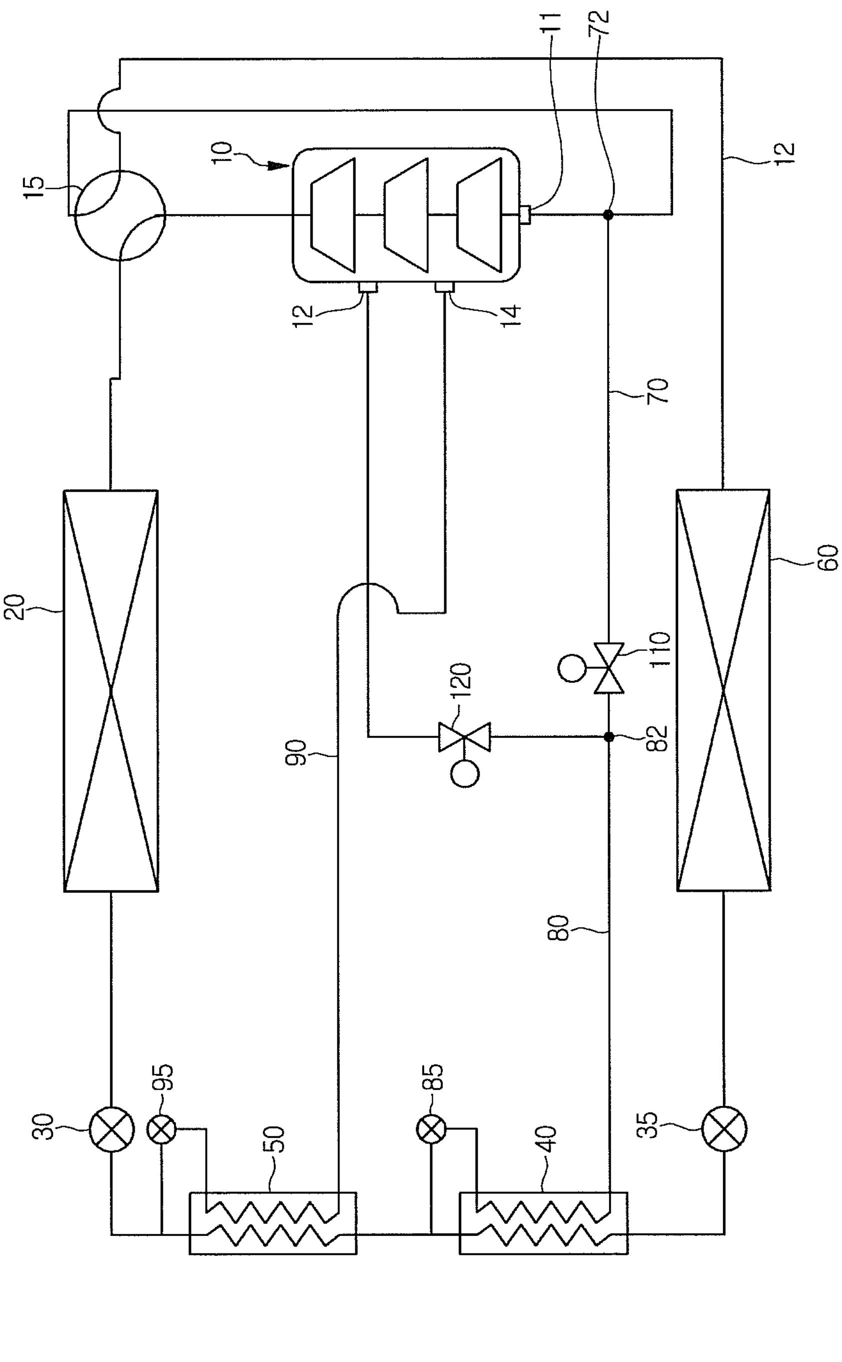
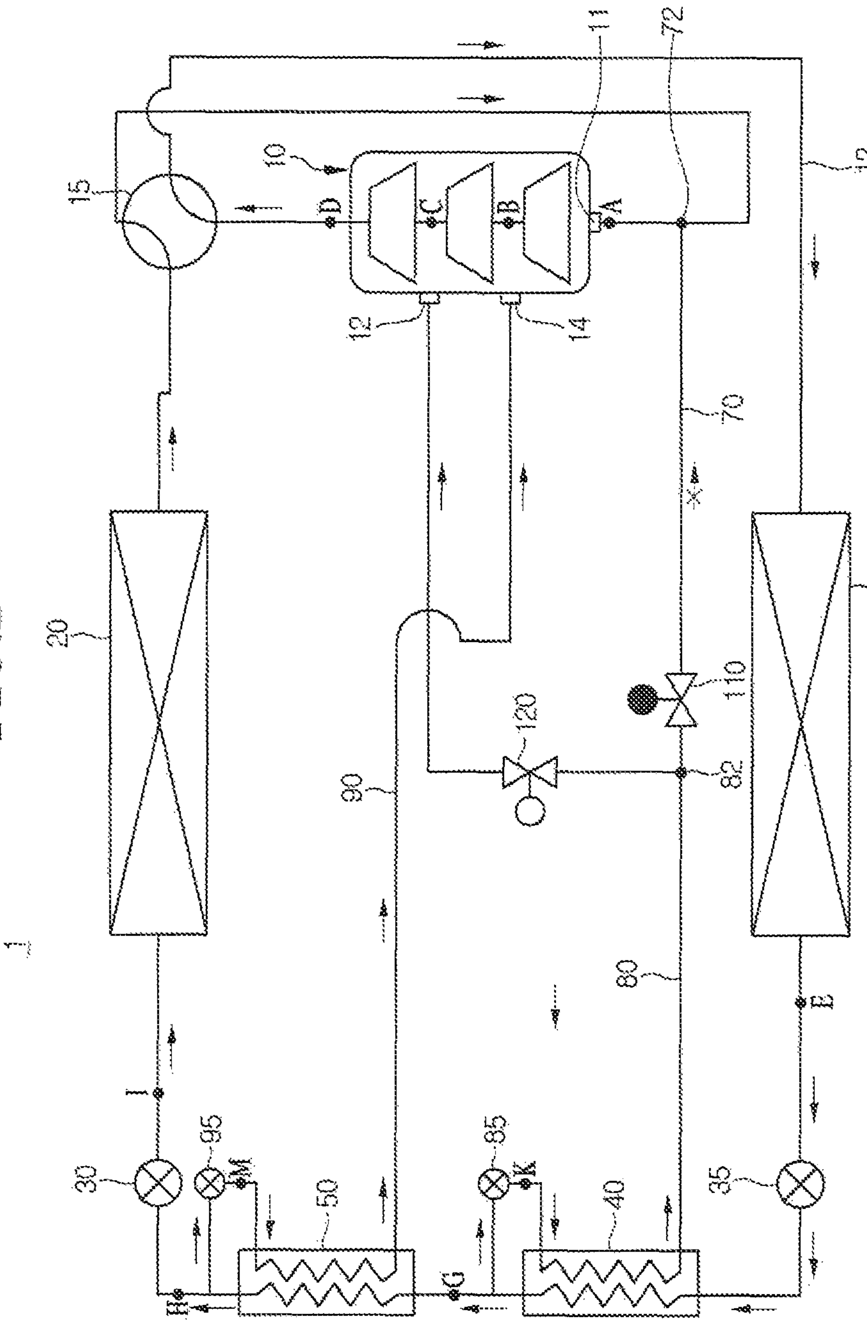


FIG.2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10
11
12
14
15
20
30
35
40
50
60
70
72
80
82
85
90
95
110
120
A
B
C
D
E
G
H
I
K
M

Fig. 3

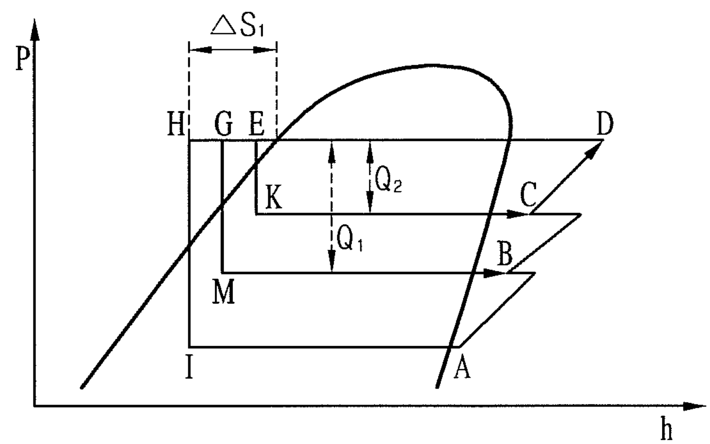


Fig. 4

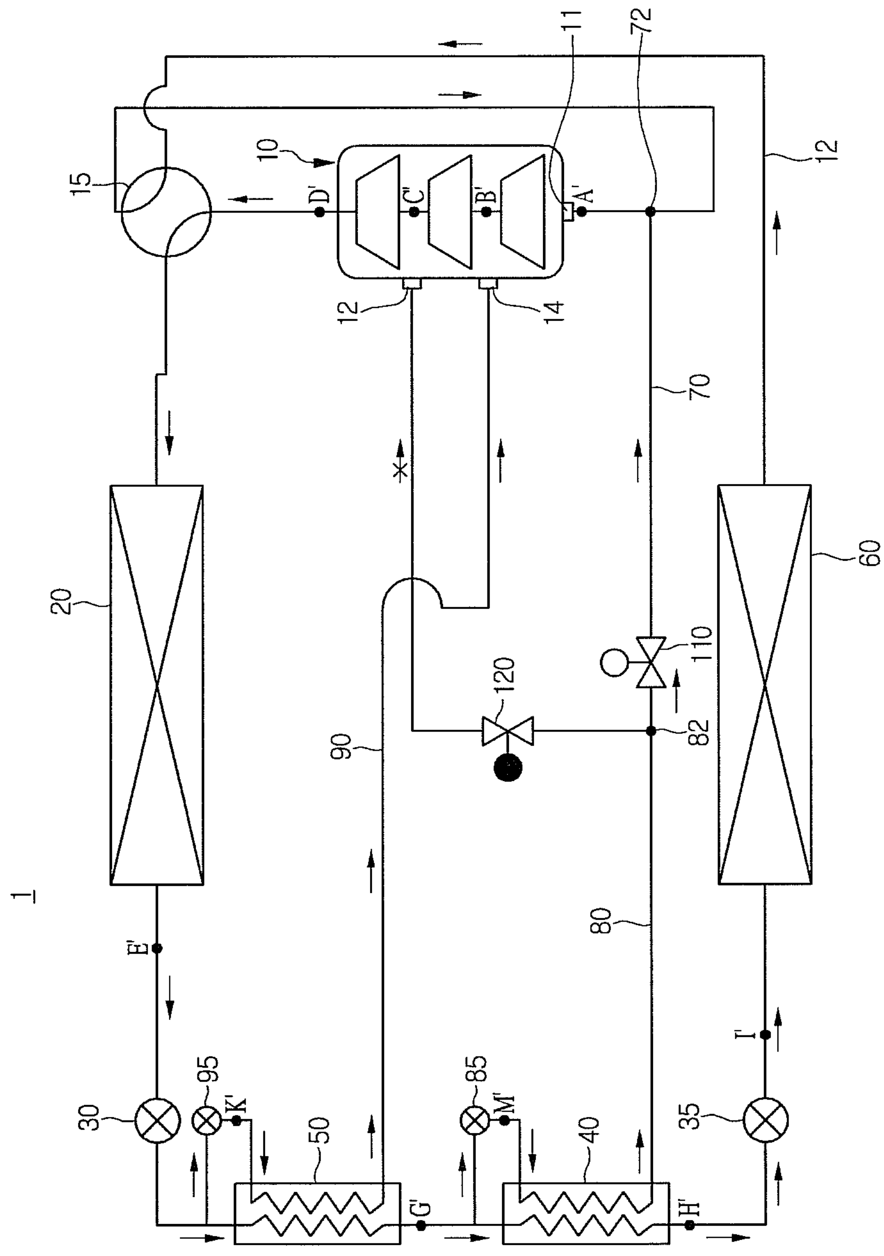

1
10
11
72
12
15
D'
C'
B'
A'
12
14
70
20
60
110
120
82
90
80
E'
I'
30
95
K'
50
85
M'
40
35
G'
H'

Fig. 5

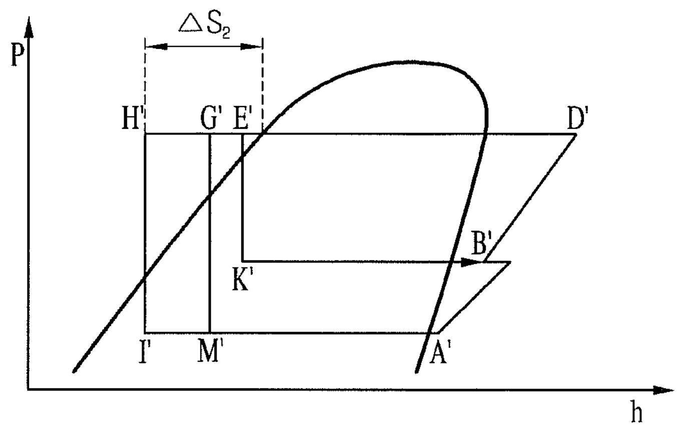


Fig. 6

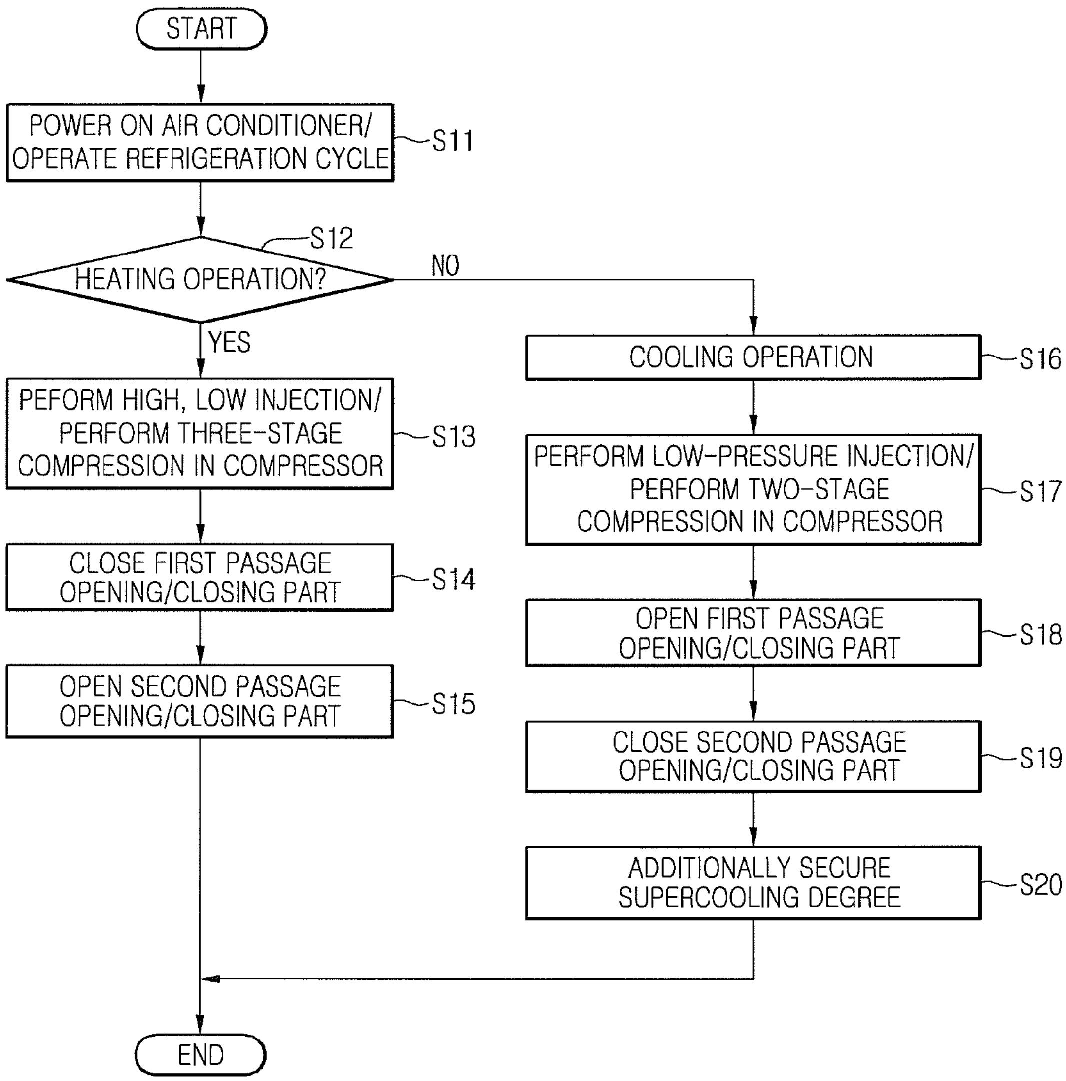
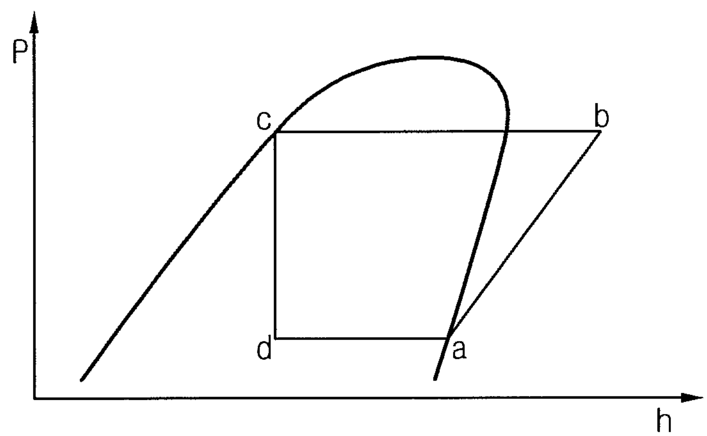

START
POWER ON AIR CONDITIONER/ OPERATE REFRIGERATION CYCLE
S11
S12
HEATING OPERATION?
NO
YES
PEFORM HIGH, LOW INJECTION/ PERFORM THREE-STAGE COMPRESSION IN COMPRESSOR
S13
CLOSE FIRST PASSAGE OPENING/CLOSING PART
S14
OPEN SECOND PASSAGE OPENING/CLOSING PART
S15
COOLING OPERATION
S16
PERFORM LOW-PRESSURE INJECTION/ PERFORM TWO-STAGE COMPRESSION IN COMPRESSOR
S17
OPEN FIRST PASSAGE OPENING/CLOSING PART
S18
CLOSE SECOND PASSAGE OPENING/CLOSING PART
S19
ADDITIONALLY SECURE SUPERCOOLING DEGREE
S20
END

Fig. 7



-Related Art-

AIR CONDITIONER AND CONTROL METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority under 35 U.S.C. 119 and 35 U.S.C. 365 to Korean Patent Application No. 10-2012-0018354 (filed on Feb. 23, 2012), which is hereby incorporated by reference in its entirety.

BACKGROUND

The present disclosure relates to an air conditioner and a control method thereof.

Air conditioners are home appliances that maintain indoor air into the most proper state according to use and purpose thereof. For example, such an air conditioner controls indoor air into a cold state in summer and controls indoor air into a warm state in winter. Furthermore, the air conditioner controls humidity of the indoor air and purifies the indoor air to become into a pleasant and clean state. In detail, the air conditioner has a refrigeration cycle in which compression, condensation, expansion, and evaporation processes for a refrigerant are performed. Thus, a cooling or heating operation of the air conditioner may be performed to cool or heat the indoor air according to the refrigeration cycle.

Such an air conditioner may be classified into a split type air conditioner in which indoor and outdoor units are separated from each other and an integral type air conditioner in which indoor and outdoor units are integrally coupled to each other as a single device, according to whether the indoor and outdoor units are separated from each other. The outdoor unit includes an outdoor heat exchanger heat-exchanging with external air, and the indoor unit includes an indoor heat exchanger heat-exchanging with indoor air. The air conditioner may be operated in a cooling mode or heating mode which are converted into each other.

When the air conditioner is operated in the cooling mode, the outdoor heat exchanger serves as a condenser, and the indoor heat exchanger serves as an evaporator. On the other hand, when the air conditioner is operated in the heating mode, the outdoor heat exchanger serves as an evaporator, and the indoor heat exchanger serves as a condenser.

FIG. **7** illustrates a pressure-enthalpy (p-h) diagram of a refrigerant cycle according to a related art. Referring to FIG. **7**, a refrigerant is introduced into a compressor in a state “a”, and then is compressed in the compressor and discharged in a state “b”. Thereafter, the refrigerant is introduced into a condenser. The refrigerant in the state “b” may be in a liquid phase.

Then, the refrigerant is condensed in the condenser and discharged in a state “c”. Thereafter, the refrigerant is throttled in an expansion device, and thus is changed into a state “d”, i.e., a two-phase state. The refrigerant throttled in the expansion device is introduced into an evaporator. Then, the refrigerant is heat-exchanged in the evaporation, and thus is changed into the state “a”. The refrigerant in the state “a” may be in a gaseous phase. Thus, the gaseous refrigerant is introduced into the compressor. The above-described refrigerant cycle is repeatedly performed.

According to the related art, cooling or heating performance may be limited.

In detail, when an external air condition is bad, that is, external air around an area on which the air conditioner is installed has a very high or low temperature, sufficient refrigerant circulation amount should be secured so as to obtain desired cooling/heating performance.

For this, a compressor having large capacity should be provided so as to increase performance of the compressor. In this case, there is a limitation that manufacturing or installation costs of the air conditioner are increased.

In addition, when the refrigerant discharged from the condenser is in an overcooled state, that is, overcooling of the refrigerant is secured, even though evaporation performance of the evaporator, i.e., a lower area of a line connecting a point “d” to a point “a” may be increased, it may be difficult to secure the overcooling of the refrigerant in a system of FIG. **6**. Thus, it may be difficult to expect performance improvement.

SUMMARY

Embodiments provide an air conditioner which can adjust a flow rate of a refrigerant injected into a compressor according to a cooling or heating operation.

In one embodiment, an air conditioner including a compressor, an outdoor heat exchanger, an indoor heat exchanger, and an expansion device includes: a supercooling device for supercooling a refrigerant condensed in the outdoor heat exchanger or the indoor heat exchanger; an injection passage through which the refrigerant passing through the supercooling device is introduced into an injection inflow part of the compressor; a bypass passage extending from the injection passage to a suction part of the compressor to bypass the refrigerant; and a passage opening/closing part disposed in at least one of the injection passage and the bypass passage to selectively block a flow of the refrigerant.

In another embodiment, a method for controlling an air conditioner including a compressor, an outdoor heat exchanger, an indoor heat exchanger, and an expansion device includes: recognizing whether a cooling or heating operation of the air conditioner is performed; and when the air conditioner performs the heating operation, injecting a refrigerant into an injection inflow part of the compressor by closing a first passage opening/closing part and opening a second passage opening/closing part, and when the air conditioner performs the cooling operation, suctioning a refrigerant into a suction part of the compressor by opening the first passage opening/closing part and closing the second passage opening/closing part.

The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a system view of an air conditioner according to an embodiment.

FIG. **2** is a system view illustrating a flow of a refrigerant in a heating operation of the air conditioner according to an embodiment.

FIG. **3** is a pressure-enthalpy (P-H) diagram illustrating a property change of the refrigerant when the heating operation of FIG. **2** is performed.

FIG. **4** is a system view illustrating a flow of a refrigerant in a cooling operation of the air conditioner according to an embodiment.

FIG. **5** is a P-H diagram illustrating a property change of the refrigerant when the cooling operation of FIG. **4** is performed.

FIG. **6** is a flowchart illustrating a control method of the air conditioner according to an embodiment.

FIG. **7** is a P-H diagram illustrating a property change of a refrigerant depending on an operation of an air conditioner according to a related art.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, an air conditioner according to embodiments will be described in detail with reference to the accompanying drawings.

FIG. **1** is a system view illustrating an air conditioner according to an embodiment.

Referring to FIG. **1**, an air conditioner **1** according to an embodiment has a refrigeration cycle in which a refrigerant is circulated. The air conditioner **1** may perform a cooling or heating operation according to a circulation direction of the refrigerant.

The air conditioner **1** includes a compressor **10** for compressing a refrigerant, a passage switch part **15** for switching a flow direction of the refrigerant discharged from the compressor **10** according to a cooling or heating operation, an outdoor heat exchanger **20** or an indoor heat exchanger **60** for condensing the refrigerant compressed in the compressor **10**, first and second expansion devices **30** and **35** disposed between the outdoor heat exchanger **20** and the indoor heat exchanger **60** to selectively expand the refrigerant, and a refrigerant tube **12** connecting the above-described parts to each other and guiding a flow of the refrigerant.

When the air conditioner **1** performs a cooling operation, the refrigerant is compressed in the compressor **10**. Then, the refrigerant passes through the passage switch part **15** and is condensed in the outdoor heat exchanger **20**. Thereafter, the refrigerant is expanded in the second expansion device **35**, and then is evaporated in the indoor heat exchanger **60**.

On the other hand, when the air conditioner **1** performs a heating operation, the refrigerant is compressed in the compressor **10**. Then, the refrigerant passes through the passage switch part **15** and is condensed in the indoor heat exchanger **60**. Thereafter, the refrigerant is expanded in the first expansion device **30**, and then is evaporated in the outdoor heat exchanger **20**.

That is, when the air conditioner **1** performs the cooling operation, the outdoor heat exchanger **20** serves as a condenser, and the indoor heat exchanger **60** serves as an evaporator. Also, when the air conditioner **1** performs the heating operation, the indoor heat exchanger **60** serves as a condenser, and the outdoor heat exchanger **20** serves as an evaporator.

Hereinafter, a configuration of a system when the air conditioner **1** performs the cooling operation will be described as an example.

The compressor **10** may be configured to perform multi-stage compression. For example, the compressor **10** may be a scroll compressor in which a refrigerant is compressed by a relative phase difference between a fixed scroll and an orbiting scroll.

The air conditioner **1** includes a plurality of supercooling devices **40** and **50** for supercooling the refrigerant passing through the condenser. For example, when the air conditioner performs the cooling operation, the plurality of supercooling devices **40** and **50** include a second supercooling device **50** for supercooling a refrigerant passing through the outdoor heat exchanger **20** and a first supercooling device **40** for supercooling a refrigerant passing through the second supercooling device **50**.

The air conditioner **1** includes a second injection passage **90** for bypassing at least one portion of the refrigerant passing through the outdoor heat exchanger **20** and a second injection expansion part **95** disposed in the second injection passage **90** to adjust an amount of bypassed refrigerant. The refrigerant may be expanded while passing through the second injection expansion part **95**.

A refrigerant bypassed into the second injection passage **90** of the refrigerant passing through the outdoor heat exchanger **20** may be called a "first branch refrigerant", and the rest of refrigerant except for the first branch refrigerant may be called a "main refrigerant". The main refrigerant and the first branch refrigerant are heat-exchanged with each other in the second supercooling device **50**.

Since the first branch refrigerant is changed into a low-temperature low-pressure refrigerant while passing through the second injection expansion part **95**, the first branch refrigerant absorbs heat while being heat-exchanged with the main refrigerant. Here, the main refrigerant releases heat into the first branch refrigerant. Thus, the main refrigerant may be supercooled. Also, the first branch refrigerant passing through the second supercooling device **50** is introduced (injected) into the compressor **10** through the second injection passage **90**.

The compressor **10** includes a second injection inflow part **14** connected to the second injection passage **90**. The second injection inflow part **14** is disposed on a first position of the compressor **10**.

The air conditioner **1** includes a first injection passage **80** for bypassing at least one portion of the refrigerant passing through the second supercooling device **50** and a first injection expansion part **85** disposed in the first injection passage **80** to adjust an amount of bypassed refrigerant. The refrigerant may be expanded while passing through the first injection expansion part **85**.

The refrigerant bypassed into the first injection passage **80** may be called a "second branch refrigerant". The main refrigerant and the second branch refrigerant are heat-exchanged with each other in the first supercooling device **40**.

Since the second branch refrigerant is changed into a low-temperature low-pressure refrigerant while passing through the first injection expansion part **85**, the second branch refrigerant absorbs heat while being heat-exchanged with the main refrigerant. Here, the main refrigerant releases heat into the second branch refrigerant. Thus, the main refrigerant may be supercooled. Also, the second branch refrigerant passing through the first supercooling device **40** is introduced (injected) into the compressor **10** through the first injection passage **80**.

The compressor **10** includes a first injection inflow part **12** connected to the first injection passage **80**. The first injection inflow part **12** is disposed on a second position of the compressor **10**. That is, the first injection inflow part **12** and the second injection inflow part **14** may be connected to different positions of the compressor **10**, respectively.

A bypass passage **70** for bypassing the refrigerant flowing into the first injection passage **80** toward an inlet side of the compressor **10** is connected to the first injection passage **80**. In detail, a branch part **82** is disposed on one position of the first injection passage **80**, and the bypass passage **70** extends from the branch part **82** toward the inlet side of the compressor **10**.

A second passage opening/closing part **120** for selectively opening or closing the first injection passage **80** is provided in the first injection passage **80**. Also, a first passage opening/closing part **110** for selectively opening or closing the bypass passage **70** is provided in the bypass passage **70**. The second passage opening/closing part **120** is disposed between the branch part **82** and the first injection inflow part **12**. The first passage opening/closing part **110** is disposed between the branch part **82** and a suction part **11** of the compressor **10**.

According to an open state of the first passage opening/closing part **10** and the second passage opening/closing part **120**, a refrigerant flowing into the first injection passage **80** may be injected from the first injection inflow part **12** into the compressor **10** via the second passage opening/closing part **120** or may be suctioned from the suction part **11** into the compressor **10** via the first passage opening/closing part **110**.

A main refrigerant passing through the first supercooling device **40** is expanded while passing through the second expansion device **35** and then is introduced into the indoor heat exchanger **60**.

The above-described flow direction of the refrigerant may be described on the basis of the cooling operation. On the other hand, when the heating operation is performed, the refrigerant may reversely flow. Hereinafter, when the air conditioner **1** performs the heating or cooling operation, a refrigerant flow and a pressure-enthalpy (P-H) diagram will be described.

FIG. **2** is a system view illustrating a flow of a refrigerant in the heating operation of the air conditioner according to an embodiment. FIG. **3** is a P-H diagram illustrating a property change of the refrigerant when the heating operation of FIG. **2** is performed.

Referring to FIGS. **2** and **3**, when the air conditioner **1** performs the heating operation, a refrigerant (a state A) suctioned into the compressor **10** through the suction part **11** is compressed and then mixed with a refrigerant injected into the compressor **10** through the second injection passage **90**. The mixed refrigerant is in a state B. A process in which the refrigerant is compressed from the state A into the state B is called a "first stage compression".

The refrigerant (the state B) is compressed again, and then the compressed refrigerant is mixed with a refrigerant injected into the compressor **10** through the first injection passage **80**. The mixed refrigerant is in a state C. A process in which the refrigerant is compressed from the state B into the state C is called a "second stage compression".

The refrigerant (the state C) is compressed again, and then is in a state D. As described above, when the heating operation is performed, the injection process is performed two times, and the compression process is performed three times. The refrigerant having the state D is introduced into the indoor heat exchanger **60** through the passage switch part **15**. The refrigerant condensed in the indoor heat exchanger **20** is in a state E.

The refrigerant passing through the indoor heat exchanger **60** passes through the first supercooling device **40**. Also, a portion of the refrigerant (the first branch refrigerant) is bypassed and expanded in the first injection expansion part **85**. The refrigerant expanded in the first injection expansion part **85** is in a state K and is heat-exchanged with the main refrigerant having a state E. In this process, the main refrigerant having the state E is supercooled into a state G. Also, the first branch refrigerant having a state K is injected into the compressor **10** through the first injection inflow part **12**, and then is mixed with the refrigerant within the compressor **10** to become in the state C.

Here, the second passage opening/closing part **120** is opened, and the first passage opening/closing part **110** is closed. Thus, the refrigerant flowing into the first injection passage **80** may pass through the second passage opening/closing part **120** and then be injected into the compressor **10**.

The main refrigerant (the state G) passing through the first supercooling device **40** passes through the second supercooling device **50**. Also, a portion of the refrigerant (the second branch refrigerant) is bypassed and is expanded in the second injection expansion part **95**. The refrigerant expanded in the second injection expansion part **95** is in a state M and is heat-exchanged with the main refrigerant having the state G. In this state, the main refrigerant having the state G is supercooled into a state H. Also, the second branch refrigerant having the state M is injected into the compressor **10** through the second injection inflow part **14**, and then is mixed with the refrigerant within the compressor **10** to become in the state B.

The main refrigerant supercooled into the state H is expanded in the first expansion device **30** and then is evaporated in the outdoor heat exchanger **20**. Then, the refrigerant is introduced into the compressor **10**.

As described above, when the air conditioner **1** performs the heating operation, since the refrigerant passing through the plurality of supercooling devices **40** and **50** is injected two times into the compressor, an amount of refrigerant circulating into the refrigeration system may be increased. Also, since the refrigerant condensed in the indoor heat exchanger **60** is supercooled into the state H (a supercooling degree ΔS**1**), heating performance of the system may be improved.

A pressure of a diagram connecting a point D to a point H may be called a "high pressure", and a pressure of a diagram (high-pressure side injection) connecting a point C to a point K, i.e., a pressure in the first injection passage **80** may be called a "first middle pressure". Also, a pressure of a diagram (low-pressure side injection) connecting a point B to a point M, i.e., a pressure in the second injection passage **90** may be called a "second middle pressure", and a pressure of a diagram connecting a point A to a point I may be called a "low pressure".

Here, a flow rate Q**1** of the refrigerant injected into the compressor **10** through the second injection passage **90** may be proportional to a pressure difference between the high pressure and the second middle pressure. Also, a flow rate Q**2** of the refrigerant injected into the compressor **10** through the first injection passage **80** may be proportional to a pressure difference between the high pressure and the first middle pressure.

Thus, the more the first and second middle pressures are defined toward the low pressure, the more the flow rate of refrigerant injected into the compressor **10** is increased. As a result, when an external air condition required for the heating operation, i.e., an external air temperature is low, an evaporation pressure (low pressure) of the refrigeration system is low. Thus, the first middle pressure and the second middle pressure may be defined within a reasonable range, and the injection effects of the refrigerant may be sufficiently achieved.

FIG. **4** is a system view illustrating a flow of a refrigerant in a cooling operation of the air conditioner according to an embodiment. FIG. **5** is a P-H diagram illustrating a property change of the refrigerant when the cooling operation of FIG. **4** is performed.

Referring to FIGS. **4** and **5**, when the air conditioner **1** performs a cooling operation, a refrigerant (a state A') suctioned into the compressor **10** through the suction part **11** is compressed and then mixed with a refrigerant injected into the compressor **10** through the second injection passage **90**. The mixed refrigerant is in a state B. A process in which the refrigerant is compressed from the state A' into a state B' is called a "first stage compression".

The refrigerant (the state B') is compressed again to become in a state D'. A process in which the refrigerant is compressed from the state B' into the state D' is called a "second stage compression". Here, the injection of a refrigerant flowing into the first bypass passage **80** into the compressor **10** may be restricted.

The refrigerant having the state D' is introduced into the outdoor heat exchanger **20** through the passage switch part **15**, and a refrigerant condensed in the outdoor heat exchanger **20** is in a state E'.

The refrigerant passing through the outdoor heat exchanger **20** passes through the second supercooling device **50**. Also, a portion of the refrigerant (the first branch refrigerant) is bypassed and expanded in the second injection expansion part **95**. The refrigerant expanded in the second injection expansion part **95** is in a state K' and is heat-exchanged with a main refrigerant having a state E'. In this process, the main refrigerant having the state E' is supercooled into a state G'. A first branch refrigerant having a state K' is injected into the compressor **10** through the second injection inflow part **14**, and then is mixed with the refrigerant within the compressor **10** to become in the state B'.

The main refrigerant (the state G') passing through the second supercooling device **50** passes through the first supercooling device **40**. Also, a portion of the refrigerant (the second branch refrigerant) is bypassed and is expanded in the first injection expansion part **85**. The refrigerant expanded in the first injection expansion part **85** is in a state M' and is heat-exchanged with the main refrigerant having the state G'. In this process, the main refrigerant having the state G' is supercooled into a state H' Also, the second branch refrigerant having the state M' is injected into the suction part **11** of the compressor **10** through the bypass passage **70**.

Here, the second passage opening/closing part **120** is closed, and the first passage opening/closing part **110** is opened. Thus, the refrigerant flowing into the first injection passage **80** may pass through the first passage opening/closing part **110** and then be suctioned into the compressor **10**. That is, the injection of the refrigerant into the high pressure side may be restricted, and the refrigerant may be suctioned into the compressor **10** to more secure the supercooling degree.

In summary, since the refrigerant having the state M' is introduced into the compressor **10**, a pressure of the refrigerant having the state M' may correspond to a low pressure (a diagram I-A pressure in FIG. **3**). Thus, the first injection expansion part **85** may be adjusted in open degree so that the refrigerant is expanded to a pressure lower than that of the refrigerant having the state M of FIG. **3**.

Also, a state (H') of the main refrigerant after being heat-exchanged with the refrigerant having the state M' may be secured in supercooling degree when compared to that of the state H of the refrigerant in FIG. **3**. That is, a supercooling degree (ΔS2) in FIG. **5** may be greater than that (ΔS1) in FIG. **3**.

The main refrigerant supercooled into the state H' is expanded in the second expansion device **35** and then is evaporated in the indoor heat exchanger **60**. Then, the refrigerant is introduced into the compressor **10**. Here, the refrigerant passing through the indoor heat exchanger **60** is mixed with the refrigerant passing through the bypass passage **70** within a junction part **72**, and then, the mixed refrigerant is introduced into the compressor **10**.

As described above, when the air conditioner **1** performs the cooling operation, an evaporation pressure is increased due to a relatively high external temperature. As a result, the injection of the refrigerant into the compressor **10** several times may be restricted. Thus, the injection of the refrigerant into the high pressure side may be omitted, and the refrigerant may be directly suctioned to further secure the supercooling degree.

When the supercooling degree is increased in the cooling operation, heat-exchange efficiency of the system may be improved. Also, since the refrigerant introduced into the indoor heat exchanger has a liquid state or low quality, noises occurring in an indoor unit may be reduced.

FIG. **6** is a flowchart illustrating a control method of the air conditioner according to an embodiment. Referring to FIG. **6**, a control method of the air conditioner according to an embodiment will be described.

When an air conditioner **1** is turned on to operate a refrigeration cycle in operation S**11**, it is recognized whether a cooling or heating operation is performed. For example, a user may manipulate a predetermined input unit to operate the cooling or heating operation. In operation S**12**, it may be determined whether the cooling or heating operation is performed according to an input content.

When the air conditioner **1** performs the heating operation, as shown in FIGS. **2** and **3**, the injection (high and low pressure injection) may be performed two times, and the three stage compression may be performed in compressor **10** in operation S**13**.

In detail, the first passage opening/closing part **110** is closed, and the second passage opening/closing part **120** is opened. Thus, the refrigerant flowing into the first injection passage **80** flows from the branch part **82** toward the second injection inflow part **14**. That is, the injection into the high pressure side may be performed, and thus, an amount of refrigerant circulating into the system may be increased in operations S**14** and S**15**.

On the other hand, when the air conditioner **1** performs the cooling operation, as shown in FIGS. **4** and **5**, the injection into the low pressure side and the two stage compression of the compressor **10** may be performed. That is, the injection into the high pressure side may be restricted in operations S**16** and S**17**.

In detail, in operations S**18** and S**19**, the first passage opening/closing part **110** is opened, and the second passage opening/closing part **120** is closed. Thus, the refrigerant flowing into the first injection passage **80** flows from the branch part **82** toward the suction part **11**. That is, the injection of the refrigerant into the high pressure side may be restricted, and the supercooling degree of the refrigerant may be more secured to improve performance of the system in operation S**20**.

According to the embodiment, an amount of refrigerant injected into the compressor may be adjusted according to the operation mode of the air conditioner to perform efficient injection and secure adequate supercooling degree.

Specifically, when the heating operation is performed, an amount of refrigerant circulating through the high-pressure injection and low-pressure injection may be increased in the compressor. Also, when the cooling operation is performed, the low-pressure injection may be performed to additionally secure the supercooling degree.

Also, the high-pressure injection may be selectively performed according to the cooling or heating operation, and the refrigerant passage may be easily varied by the passage opening/closing part according to whether the high-pressure injection is performed. Thus, the air conditioner may be effectively controlled according to the cooling or heating operation mode.

Also, since the refrigerant having the middle pressure may be injected into the compressor, a power required for compressing the refrigerant may be reduced in the compressor. Thus, the cooling or heating efficiency may be improved.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. An air conditioner comprising a compressor, an outdoor heat exchanger, an indoor heat exchanger, and an expansion device, the air conditioner comprising:

at least one supercooling device that supercools a refrigerant condensed in the outdoor heat exchanger or the indoor heat exchanger;

at least one injection passage through which the refrigerant passing through the at least one supercooling device is introduced into an injection inflow port of the compressor;

a bypass passage that extends from the at least one injection passage to a suction port of the compressor to bypass the refrigerant;

a branch provided at the at least one injection passage to guide the refrigerant from the at least one injection passage to the bypass passage; and

at least one valve disposed in at least one of the at least one infection passage or the bypass passage to selectively block a flow of the refrigerant, wherein the at least one valve comprises a first valve disposed in the bypass passage to selectively restrict suction of the refrigerant into the suction port and a second valve disposed in the at least one injection passage to selectively restrict injection of the refrigerant into the injection inflow port, wherein the second valve is disposed between the branch and the injection inflow port of the compressor and the first valve is disposed between the branch and the suction port of the compressor, and wherein in a first operation mode, the first valve is opened and the second valve is closed such that the refrigerant flows from the at least one supercooling device into the bypass passage from the at least one injection passage and is introduced into the suction port, and in a second operation mode, the first valve is closed and the second valve is opened such that the refrigerant flows into the injection inflow port through the at least one injection passage.

2. The air conditioner according to claim **1**, wherein the at least one supercool device comprises first and second supercooling devices disposed between the outdoor heat exchanger and the indoor heat exchanger.

3. The air conditioner according to claim **2**, wherein the first operation mode comprises a cooling operation, and wherein one-stage compressed refrigerant introduced into the suction port of the compressor is mixed with a refrigerant injected from the second supercooling device and is compressed in two stages in the compressor when the air conditioner performs the cooling operation.

4. The air conditioner according to claim **2**, wherein the second operation mode comprises a heating operation, and wherein when the air conditioner performs the heating operation, one-stage compressed refrigerant introduced into the suction port of the compressor is mixed with a refrigerant injection from the second supercooling device and is compressed in two stages in the compressor, and the two-stage compressed refrigerant is mixed with a refrigerant injected from the first supercooling device and is compressed in three stages.

5. The air conditioner according to claim **2**, wherein the at least one injection passage comprises:

a first injection passage through which a refrigerant passing through the first supercooling device is injected into a high-pressure side of the compressor; and

a second injection passage through which a refrigerant passing through the second supercooling device is injected into a low-pressure side of the compressor.

6. The air conditioner according to claim **1**, wherein the first operation mode is a cooling operation mode, and the second operation mode is a heating operation mode.

7. The air conditioner according to claim **1**, further comprising a passage switch that alternates a flow direction of the refrigerant based on whether the first operation mode or the second operation mode is being performed.

8. The air conditioner according to claim **1**, wherein the expansion device further comprises a first expansion device adjacent to the outdoor heat exchanger, and a second expansion valve adjacent to the indoor heat exchanger.

9. A method for controlling an air conditioner, the air conditioner comprising a compressor, an outdoor heat exchanger, an indoor heat exchanger, an expansion device, at least one supercooling device that supercools a refrigerant condensed in the outdoor heat exchanger or the indoor heat exchanger, at least one injection passage that extends from the at least one supercooling device to an injection inflow port of the compressor, and a bypass passage that extends from the at least one injection passage to a suction port of the compressor, the method comprising:

recognizing whether a cooling or heating operation of the air conditioner is performed; and

injecting a refrigerant discharged from the at least one supercooling device into the injection inflow port of the compressor by closing a first valve installed in the bypass passage and opening a second valve installed in the at least one injection passage when the air conditioner performs the heating operation, and suctioning a refrigerant discharged from the at least one supercooling device into the suction port of the compressor by opening the first valve and closing the second valve when the air conditioner performs the cooling operation.

10. The method according to claim **9**, wherein the refrigerant is compressed in two stages in the compressor when the air conditioner performs the cooling operation, and the refrigerant is compressed, into three stages in the compressor when the air conditioner performs the heating operation.

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